Treatment of Sacculated Aortic Aneurism by Electrolysis through Introduced Wire.

Report of a Case.

BY

D. D. STEWART, M.D.,

CLINICAL LECTURER ON MEDICINE AT THE JEFFERSON MEDICAL COLLEGE.

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TREATMENT OF SACCULATED AORTIC ANEURISM BY ELECTROLYSIS THROUGH INTRODUCED WIRE.[1]

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By D. D. Stewart, M.D.,
clinical lecturer on medicine at the jefferson medical college.

The therapy commonly adopted for the cure of aortic aneurism, whether of the arch or the descending portion, usually offers so little promise of success, that any method suggested to supplement or substitute this, if attended with little risk to the patient and supported by the slightest clinical evidence, merits careful consideration. The frequent utter inutility of medical treatment in cases of aneurism which, from their situation or character, are insusceptible of extinction by deligation or by compression, necessitates an earnest search for another method.

As the cure of aneurism can only result through obliteration of the sac cavity by the formation therein of firm thrombi, which in process of time undergo organization with contraction of the sac wall, so all plans of treatment suggested have as their basis the production of organizable clot. The ideal method of promoting this would be that of introducing into the sac a harmless substance that would act by virtue of its vital or chemical properties; such a substance has not yet been found among the medicinal hæmostatics. Experiments made by the late Dr. Wooldridge[2] tend to indicate that it may exist in lecithin or in tissue fibrinogen—that the fibrin factors of the blood may, under skilful manipulation, be so modified that these can be introduced without risk of the coagulum so induced spreading beyond the sac boundaries into the vessel. As yet this hope has not been realized.

Multiple galvano-puncture, with the use of strong currents, the anode the active pole, the cathode externally—in brief, the process conducted in a manner conducive to the best results with least risk, if good results were possible—has, beyond doubt, proved a failure in the therapy of aneurism.[3] Although the method is practically devoid of danger when

[1] Read before the College of Physicians of Philadelphia, March 2, 1892.

[2] See paper by Powell, "On the Diagnosis and Treatment of Aneurism of the Aorta," Lancet, January 4, 1890.

[3] Practised as advocated in text-books on electricity the treatment is useless indeed. A recent work—Liebig and Rohé's—recommends a current-strength of but twenty to

carefully carried out, it is also, it must be added, apparently practically devoid of benefit; for though firm coagula are perhaps often induced, they are of such small dimensions, and offer so little obstruction to the blood-current, that their dissolution rather than their accretion and organization usually quickly results. The slight amelioration in symptoms, though promptly occurring, is of most ephemeral duration. Occasionally a "cure" is reported, yet this is so exceptional that the method must now be looked upon as scarce worthy of further trial.[1]

It must be briefly inquired, if the method originated and first practiced by Moore, of London—that of permanent introduction of filiform material into the sac which acts merely mechanically, by offering multiple surfaces for clotting and by impeding the blood stream, permitting the latter to whip itself about the former—is more promising than that of galvano-puncture. That it is theoretically so there is no doubt, the two factors most important in cure being here furnished. It is not surprising, therefore, that since Moore, in 1864, attempted, by the method which has since been called by his name, to delay the fatal issue in a hopeless case of thoracic aortic aneurism, that the possibilities this treatment suggests should have caused it to be viewed with favor. It is, on the other hand, more curious that an interval of seven years should have been permitted to elapse before the method was tried a second time, possessing the theoretical advantages that it does. The cause probably lay in the subsequent unfortunate result in Moore's case—inflammation of the sac and pyæmia—one that in those days seemed inherent in the operation, but which was, in truth, rather due to the bad technique—faulty in the excessive amount of wire used,[2] with which were also probably introduced septic germs.

thirty milliampères, and this applied for but ten minutes. The inter-polar resistance is so great with one electrode externally, that an electrolytic action to any purpose necessitates a current strength, and the duration of its application, much in excess of this. Fifty milliampères are none too great nor an hour too long, if permanent results are to be hoped for. No greater risk attends the application of a strong current and a long session, than a weaker current and a short session, provided the needles are properly insulated. See my own case, in which a current of seventy milliampères was passed through two needles and two and a half feet of wire for an hour entirely without ill result.

[1] As to these reported *cures*, are they permanent? Unfortunately too few trouble themselves to obtain information as to later developments in rare cases of "cure" in other affections beside aneurism. The report is too often made *ad captandum*—the wonder excited is the reward desired.

[2] Twenty-six yards of fine iron wire were inserted—sufficient to originate much local disturbance. The wire was soft and bent in all directions (see remarks by Holmes and Hulke: Cayley's paper on a case treated with wire—Lancet, February 27, 1886). The aneurism was very large and seemed on the point of bursting through the skin or into the pericardium. Rapid coagulation in the sac occurred and temporary arrest of pulsation. Death resulted on the fifth day. (Med.-Chir. Trans., xlvii. p. 129.)

Of the twelve recorded cases in which wire was inserted,[1] without the conjoint employment of electrolysis, all were apparently in a more or less hopeless condition prior to operation. Yet, notwithstanding this, as regards clot-formation, reduction in the bulk of the sac, and its final obliteration, if such may be termed a cure, it would appear that two recoveries resulted, and the condition of several other of the cases was temporarily improved. In Loreta's case[2] an abdominal aneurism, the size of a fœtal head at term contracted to the dimensions of a walnut, with obliteration of the sac cavity, by the seventieth day after the introduction of two yards of silvered copper wire. Death resulted subsequently from rupture of the aorta below the sac. In Morse's[3] case it is stated that eight weeks after the insertion of one and a half yards of one-half millimetre silver-plated copper wire into the sac of an abdominal aneurism the size of two fists, all indications of aneurism had disappeared, a hard nodule replacing the pulsating tumor. The patient remained well. In Cayley's case[4] of rapidly increasing thoracic aortic aneurism on the verge of rupture, forty feet of steel wire caused complete consolidation of that portion of the sac pointing externally, without constitutional disturbance or local pain. Two months later nearly thirty-five additional feet of wire were passed into the intra-thoracic portion of the aneurism, which now showed signs of rapid increase. Death resulted from dyspnœa from the tracheal pressure, without any change occurring in the symptoms or physical signs. The size and connections of the sac were stated by Cayley to have rendered the second operation ineffectual. That part of the sac in which the wire was first introduced was found to have undergone complete solidification. In the cases of Domville,[5] Murray,[6] Pringle (and Morris),[7] Lange,[8] and Ransohoff,[9] in which death followed the operation in a short time, the necropsies showed undoubted evidence of benefit having resulted from the introduction of wire. In Hulke's case[10] (thirty-three feet of wire) no *intra-vitam* or *post-mortem* change attributable to the use of wire could

[1] Omitting those in which watch-springs were used, the method of Bacilli, which has nothing to recommend it, either in theory or result, over the employment of ordinary wire. The elasticity of watch-springs necessarily interferes with subsequent contraction of the sac and its contents, without which an absolute cure cannot result. Their brittleness also renders fracture likely during the process of sac-contraction. The walls of the aneurism are then endangered from contact with the sharp pieces.

[2] British Medical Journal, 1885.

[3] Pacific Medical and Surgical Journal, February, 1887, abstracted in the Medical News, March 5, 1887. This operation was performed after Loreta's method, the aneurism being exposed through an abdominal section.

[4] Lancet, February 27, 1886.

[5] Stimson's Reference Handbook, vol. i.

[6] British Medical Journal, 1872, vol. i.

[7] Lancet, April 19, 1887.

[8] British Medical Journal, November 20, 1886.

[9] Medical News, May 29, 1886.

[10] Lancet, April 19, 1887.

be noted. In that of White and Gould, in which thirty-two feet of steel wire were introduced, harm rather than benefit resulted—due, it was thought probable, to the use of an excessive amount of wire, and to too firm pressure being subsequently applied to the sac.

Closely following the second and third operation with wire, came a modification of Moore's method by Levis—that of the introduction of horsehair instead of wire. Subsequently catgut was used by Murray, of Newcastle, and Florence silk by Schrötter, of Vienna. It was supposed that with these substances a nidus for deposit of fibrin would be offered with less risk of subsequent irritation, and with a better opportunity for contraction of organized thrombi and sac wall. It is not easy now to form an estimation as to the exact utility of these agents so used as methods of cure, based on the earlier operations, done as they were before the days of clean surgery. There can be little doubt that the ill result attending several of these was due, as in Moore's case, largely to septic complications. However this may be, the results with horsehair, silk, and gut have not been so encouraging, under like conditions, as those with wire, and this may be due to the fact that material of this sort can scarcely offer so suitable a framework as wire for the formation and support of coagula. It is not easy to fill a sac of some dimensions with such material as silk or gut, which is far more likely than the stiffer wire to be deflected to one side in its introduction by loose coagula present in more or less amount in all cases of old aneurism, so that its equal distribution about the sac is difficult or impossible. For this reason, if coagulation does not at once occur about it, less obstruction would be offered to the flow of blood in the sac, and thus an important factor in cure be lacking. But it is not for these reasons that I would advocate the superiority of wire. Despite the proved occasional utility of horsehair and silk, as in the cases of Bryant and Schrötter, in both of which firm laminated coagula engaged these substances, indicating that coagulation had been favored by their presence in the respective sacs; despite the innocuousness of such material when introduced with the strictest antisepsis, and its susceptibility of admitting of the utmost contraction of clot and sac wall without danger of subsequent irritation, it is not to be preferred to wire for the reason that all the objections which have been urged against the latter may be obviated by the use of a fine and but moderately drawn silver wire, which will permit compression into quite as small a bulk as horsehair or gut, with as little risk of subsequent irritation, and which, in addition, possesses the extraordinary advantage that a method can be conjoined with it whereby certain and prompt fibrin-formation will be promoted in the sac cavity. When it is considered that in many of the cases in which wire was used without electrolysis, especially the earlier ones—which were, of course, done without attention to antisepsis—far more wire was employed than was essential

or harmless,[1] and that in many the operation was undertaken as a forlorn hope, the results obtained indicate that the method is not without utility. When practised in a manner that experience has taught us is free from risk and most likely to be beneficial, and then, also, combined with electrolysis, by aid of which firm coagulation in the sac can surely be effected, it would appear a most promising mode of treating aortic aneurism not yielding to the Tufnell method or to potassium iodide. With the anode as the active pole, the coagulum produced by galvanopuncture is much firmer than that which forms about unelectrified smooth wire; yet even with many needles in an ordinary-sized sac, as Barwell[2] points out, several trifling nodules of fibrin occurring at the periphery of the sac can have little effect on a large mass of circulating blood. With the combined method the chief objection to the use of a limited amount of fine aseptic wire disappears. Instead of a soft, unstable coagulum about the wire, tardy in appearing, there may be produced almost immediately a tough clot, which, in favorable cases, should tend by accretion to produce prompt obliteration of the sac cavity.

But seven cases of the combined operation are reported; these, with my own, the eighth, are as follows:

Case I.—Burresi's (Corradi's).[3] Male, aged forty-three years; large aneurism of the ascending part of the aortic arch, non-responsive to carefully applied and varied medical treatment, or to the endermic application of electricity (method of Vizioli-Gallozzi). Case not thought propitious for any treatment, as sac-wall was much thinned, communicating opening large, and tumor rapidly growing. A consultation resulted in the adoption of a method of treatment proposed by Corradi;[4] the latter inserted a canulated needle (diameter 8 mm.) into the aneurism in the second intercostal space, in direction almost horizontal from left to right and from before backward, penetrating the sac a distance of 2 cm.; 42 cm. (17 inches) of No. 30 annealed wire were passed. During its introduction the needle was circumducted with the object of winding the wire into coils on its entrance into the sac. The needle was then withdrawn and the extremity of the wire outside the aneurism connected with the anode of a galvanic battery of sixteen elements, tested by a voltmeter to yield 1 c.c. of hydrogen gas for the first minute. Cathode to chest-wall. Current passed for twenty-five minutes. At the end of the first fifteen minutes of its application all pulsations had disappeared except that communicated from the adjacent part of the aorta. Operation was well borne. Pain entirely gone at end of third day. Patient continued to do well for a time, but subsequently all symptoms returned. Death at end of three and a quarter months.[5] No necropsy.

[1] In Murray's case, twenty-four feet; in Cayley's, at first forty feet, subsequently thirty-five feet; in Hulke's, thirty-three feet; in White and Gould's, thirty-two feet.

[2] British Medical Journal, June 5, 1888.

[3] Lo Sperimentale, April, 1879, p. 445 et seq.; and also Giorn. Internaz. della Sci. Med., 1881, p. 1109 et seq.

[4] To Corradi is due the credit of first proposing the combination of galvanism with introduced wire, and of treating a case by the combined method. Barwell later, apparently unaware of Corradi's case, suggested a treatment on similar lines, though with a much superior technique to the latter.

[5] It is interesting to note that this case was reported cured in Lo Sperimentale, twenty-five days after the operation. The subsequent account of it is briefly given in a paper by Marcacci in Giorn. Internaz. della Sci. Med., 1881, p. 1109 et seq.

CASE II.—Barwell's.[1] Male, aged thirty-nine years; luetic history. Very large progressive aneurism of the ascending and transverse part of the aortic arch; advanced pressure symptoms; medical treatment of no avail. When almost at the point of death, ten feet of the finest steel wire, which had been spirally wound, were passed through an ivory needle into one division of the sac. Anode active pole; cathode upon upper dorsal region; ten milliampères passed for one and one-sixth hours. Redness of skin produced at site of negative pole; no irritation at point of puncture. Signs of consolidation appeared at expiration of twelve hours: pulsation more distant; tumor firmer; pressure symptoms much diminished. On the fourth day after operation rapid increase in size of a secondary sac to the right of the former. Death on the seventh day from exhaustion and rupture of the secondary sac. Necropsy showed pronounced pressure effects on lungs. Primary sac contained much thick, firm, decolorized fibrin intimately united to sac and wire.

CASE III.—Roosevelt's.[2] Male, aged twenty-five years; luetic history. "Aggravated aortic aneurism threatening death," involving upper four ribs on the right of sternum. Despite medical treatment, rapid advancement. Through a short, insulated aspirator-needle 225 feet of fine steel piano-wire (No. 00) were passed, connected with "one pole of constant battery," which not stated; the other over right shoulder. "About twenty-five milliampères were passed for a half-hour." Potassium iodide (begun before operation) continued. Tumor pulsated less strongly the second day; pain and vertigo present. Third day, tumor less painful, but still pulsated; breathing "not so comfortable." Fourth day, dyspnœa and cyanosis. Seventh day, less pain and cyanosis; in better condition than before operation. During the third week could swallow and breathe with greater ease; tumor felt firmer. In fourth week vomiting and headache; potassium iodide discontinued. On twenty-second day "painful dark-colored spot appeared on one toe." Death on the twenty-third day. Necropsy not permitted.

CASE IV.—Abbe's.[3] Male, aged forty-six years; no lues. Rapidly advancing aneurism at root of neck; oval cavity four inches by five inches; medical treatment unavailing; ligation of carotid, and shoulder amputation decided against. Case adjudged utterly hopeless. Barwell's operation resorted to for the purpose of lengthening life and to lessen pain; 100 feet of No. 1 aseptic catgut were introduced a few days before the wire, following which a part of the tumor seemed firmer, but rapid advancement occurred in other portions, with pronounced pressure symptoms. On the ninth day following the use of catgut, 150 feet of fine sterilized wire were introduced through insulated aspirator-needle. Anode at first the active pole; cathode to back; fifty milliampères for one half-hour; one hundred milliampères second half-hour, cathode active pole, anode to back. No pain; pulsation continued, though tumor wall firmer. On second day rupture of the sac into trachea; pronounced pressure symptoms on trachea had long preceded rupture. Necropsy not permitted.

CASE V.—Kerr's.[4] Male, aged thirty-eight years; luetic history. *Fusiform* aneurism from the base of heart to origin of left subclavian artery. Pressure symptoms. Medical treatment continued three months without result. Six feet of drawn silver wire were introduced through medium-sized hypodermic needle insulated with shellac. Anode the active pole, cathode to epigastrium; current passed fifty minutes, its strength or the number of cells employed not stated. Impossible to force cut end of wire into sac through canula; canula therefore withdrawn; wire cut close to skin and forced in. Pain and pulsation stated to have been greatly relieved, though death occurred on the eighteenth day. Necropsy revealed fusiform aneurism as above. Wire had entered anterior surface of the sac. About the wire, as well as on the sac-wall, a firm clot had formed.

CASE VI.—Kerr's.[5] Male, aged fifty-six years. "Aortic intra-pericardial

[1] Barwell: Loc. cit.

[2] Medical News, April 9, 1887.

[3] Medical News, April 9, 1887.

[4] Occidental Medical Times, January, 1889.

[5] Loc. cit.

aneurism," forming pulsating tumors on the right of sternum extending from the second to the fourth intercostal space. Pressure symptoms. No improvement from medical treatment. Electrolysis tried: two insulated needles in sac, anode active, negative on epigastrium; current passed for one hour. No improvement followed. Electrolysis through wire then used, *modus operandi* as above; ten feet of drawn silver wire were introduced; current passed for a half-hour, its strength or number of cells not stated. Within two months the patient left hospital "feeling as well as ever." Promised to report should symptoms return; no word at date of publication of paper.[1]

Case VII.—Rosenstein's.[2] Obese young male, aged twenty-five years. Venereal and alcoholic excesses. Aneurism of the ascending part of the aortic arch, unimproved by the Tufnel-Balfour treatment. Pronounced pressure symptoms. Galvano-puncture tried; single needle; anode active; seventy milliampères for twenty minutes. Thirteen days later this procedure was repeated with two needles. No improvement. Five and a half weeks later, through exploratory trocar for six minutes a slowly increasing current up to seventy milliampères was passed; lance of trocar removed and two and one-sixth feet of spirally wound, moderately thick, softened silver wire, such as is used in trachelorrhapy (about No. 28), were passed through the canula. The wire was pushed entirely into the sac with the lance, and the current applied for thirty minutes. Pain subsided in a few days; breathing became easier; tumor grew gradually smaller and harder, and the pulsation less. Pulsations had disappeared in the seventh week, complete recovery following.[3]

The history of my case, not before published, involving a number of points of interest, is related somewhat in detail.

Case VIII.—F. D. F., American, white male, of spare build, height about five feet seven inches; best weight about 140 pounds; occupation, insurance agent. First seen in July, 1888, then aged thirty years. About two years prior to this date pain had developed in the back in consequence of attempting to carry a heavy load. Lumbar pain thus induced, though slight at first, became severe after three or four days, and so continued steadily for about a month. Subsequently pain was chiefly localized in the left lumbar region anteriorly and posteriorly. Besides a dull, more or less continuous ache, there were lancinating pains in the area of distribution of the upper lumbar nerves. Several months before he was first seen, at a time when the pains were very slight or were absent, he indulged in violent wrestling, an exercise of which he was fond. Immediately afterward, while seated, he felt something give way in the former painful area. Shortly subsequent to this a small pulsating tumor appeared in the upper part of the left lumbar region. There was no history of lues. He was a trifle given to excessive venery, but was otherwise temperate. The bowels were much consti-

[1] Dr. Kerr informs me by letter that he lost sight of this patient about one year following the operation, and that all later inquiries regarding him have been fruitless.

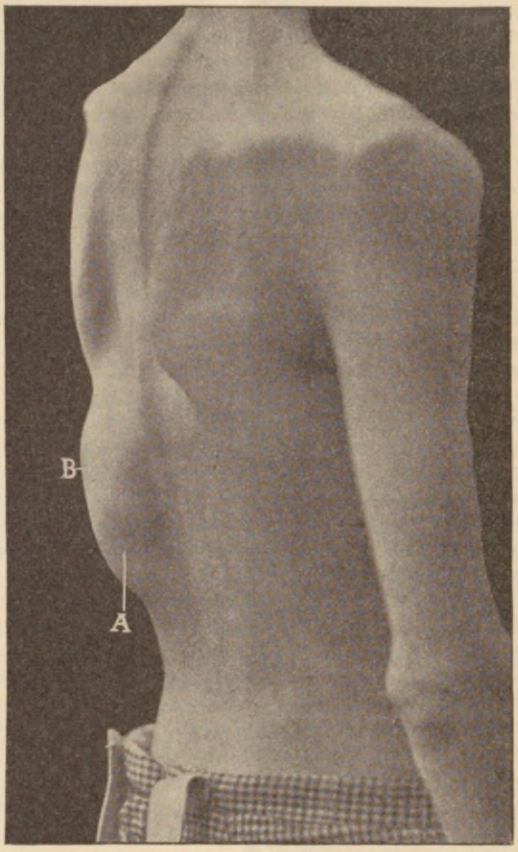
[2] The American Journal of the Medical Sciences, January, 1891.

[3] Under date of February 15, 1892, two years following the operation, Dr. Rosenstein informs me that his patient has continued cured. That he has had "no return of symptoms, except that in March last, after a comparatively mild though prolonged indulgence *in Baccho*, there was a slight irregularity of the pulse and a very faint bruit. Energetic measures as to total abstinence, more rest, and a little potassium iodide with digitalis, helped him in about three months, and he has remained well ever since."

pated. Examination revealed a small, expansile, pulsating swelling to the left of the upper left lumbar vertebræ. Over it the second sound of the heart was plainly distinguishable, but no murmur. The latter was present somewhat above, at the border of the twelfth rib. There was no pulsation or murmur to be heard anteriorly. The heart was overacting, but otherwise normal. No difference could be detected in the femoral pulses. Aneurism of the abdominal aorta was diagnosticated, and the patient received into the wards of the Jefferson Hospital. He was put at rest in recumbency on a spare diet, after the method of Tufnell. Potassium iodide was prescribed at first in doses of gr. x., three times daily, and subsequently in larger amount. The bowels were moved daily by laxatives, and codeine ordered in moderate doses for the relief of pain. The patient could be persuaded to keep at rest only with difficulty, and after a three months' sojourn in the ward, during which the pain much ameliorated and for a time disappeared, though no marked alteration occurred in the aneurism, he left the hospital. As it was thought that rest in recumbency rather than potassium iodide had benefited him, barium chloride was prescribed three weeks before his departure, at first in doses of one-tenth of a grain, and after a few days one-sixth of a grain, with seemingly remarkable benefit in the symptoms. Under this drug (other conditions as before), pain—which, despite every care taken to improve his condition, began to be as severe as formerly—now almost disappeared, and the area of aneurismal impulse somewhat diminished. He could not be persuaded to continue longer in the hospital, as his means were limited, and he felt sufficiently improved to continue his work. He was not seen again until seven months later (May, 1889). He then stated there had been little or no constant pain in the interval, and that he had been able to continue his work without interruption. During this period he had taken the barium chloride in doses of from one-sixth to one-third of a grain. The tumor had not increased in size. In the erect posture the impulse was slight, detectable only by palpation; in recumbency, prone, it was perceptible to the eye, but not nearly so extended as at first, and its sounds were more distant, indicating that partial solidification had occurred. The heart was somewhat irritable, with a relatively accentuated apical second sound. The pulse was: standing, 100; sitting, 96. The bowels, as before, were unmoved without purgatives. Barium chloride was now increased to one-half grain doses.

I subsequently saw him but four times up to October 26th: once in June and three times in October. During this period, contrary to my advice, he actively pursued his vocation, which necessitated a great deal of walking. When seen in the autumn the improvement had ceased to be maintained. Without my knowledge or advice he had increased the dose of barium chloride to three-fourths of a grain a month before I saw him, on October 17th. The area of bulging and impulse was then larger, and the heart was very irritable. Barium was now discontinued. He consented to rest for a few weeks, and pursue the Tufnell treatment; but, after a short time spent in bed, he returned to work, and was not seen again until September last. He then had been confined to the house for two months, being too much prostrated and the pain too severe to go about. During the interval of two years in which I had not seen him he had taken little or no care of himself. His physical condition had grown progressively worse. Despite this, he

continued his employment quite steadily until within a few months of September. More or less gnawing pain was felt in the region of the aneurism, with paroxysmal attacks of left-sided abdominal pain. The bulging posteriorly had reached a length of five and a half inches; its greatest breadth four and a half inches. There were three large nodules upon it, far more prominent than are shown in the photograph.



A. Site and direction of entrance of canula through which wire was introduced.
B. Site and direction of entrance of second needle.

Bulging began opposite the spinous process of the ninth dorsal vertebra, and extended to the lower lumbar spines. The abdomen and ribs were more prominent on the left side, which measured from mid-spine to mid-sternum one and three-fourths inches in excess of the right side. A marked impulse was perceptible to the eye and by palpation in all parts of the aneurism, the walls of which seemed thin and but ill-protected by clot. A murmur was heard over the most prominent portions. No sounds were detected laterally or in front over the prominent left abdomen. The area of splenic dulness was considerably increased. The heart was irritable, its sounds high-pitched, the first lacking in

muscular element: the impulse was slightly lowered and displaced to the left. There was a markedly accentuated pulmonary second sound, without any sign of an obstructive cardiac affection. The pulse was somewhat irregular and compressible. There were also cough, muco-purulent expectoration, and some dyspnœa. Mucous râles were present in the upper part of both lungs, accompanied by diminished resonance on percussion at the left apex. There was an area of anæsthesia extending over the aneurism from about the ninth dorsal spine above and the second lumbar below laterally and anteriorly toward the median line, in a direction slightly downward. Above and below this there was intensely heightened tactile and pain sense, the slightest touch or firm pressure causing much suffering. The superficial reflexes of dorsum, chest, and abdomen on the left side were extraordinarily heightened, very trifling stimulation producing markedly increased response on the same and the opposite side. The right knee-jerk was +, the left + +. Ankle clonus was absent. There was no paraplegia. The pain felt in the back was quite constant, lasting for hours, and was gnawing in character. Excruciatingly severe pain was felt in the left hypochondrium, loin, and abdomen. To relieve this he had been taking codeine in the extraordinary doses of gr. xx. to gr. xxx. daily. This was ordered discontinued, small doses of denarcotized opium at short intervals replacing it. He was removed to St. Mary's Hospital in September.

During his sojourn there his physical condition improved somewhat, but the area of bulging seemed to grow larger almost daily. As the physical signs indicated rapid advancement, and that rupture of the sac was imminent, the performance of electrolysis through introduced wire was suggested to him as offering a chance of at least slightly delaying the fatal issue, and, perhaps, also promoting euthanasia. He was told a cure was now impossible. With this understanding he was anxious for the operation. It was done on December 7th last, with the assistance of Dr. Pottberg, to whose mechanical skill I am indebted for many suggestions of value in the technique. Mr. Otto Flemming, who contributed the electrical outfit and needles, was also present. As my prime object in this case—in which a cure could not be expected—was rather to promote prompt formation of firm protecting coagula, in order to retard rupture of the thin-walled sac, than to cure an aneurism of such dimensions, with symptoms indicating advanced implication of vital parts, I chose a rather heavy silver wire;[1] for, on consideration, I concluded a better chance of immediate success lay in the introduction of wire of sufficient calibre to form large, supporting spirals in the sac, thus occupying considerable of its cavity, and affording a framework for clot, than in the use of a thinner, more pliant wire, which, though better calculated to permit of ultimate contraction of organized fibrin and sac walls—apparently not to be hoped for here—might undergo deflection from its course in introduction through impingement on loose coagula already in the sac, thus perhaps rendering it necessary to

[1] "Drawn hard to No. 23 Brown & Sharp gauge." It was so drawn that it would readily form spiral coils. It was afterward kept for several days on a roll two and a half inches in diameter, so that when removed and passed through a canula it assumed separate spirals each of about three to five inches in diameter, a few feet of it covering quite a large area.

repeat the process, which from the patient's enfeebled condition would have been impracticable. A canulated steel needle, two and a half inches in length, of sufficient size to permit the passage of the wire, insulated with shellac to within half an inch of its point, was used to pass the wire. The wire and needles were sterilized by boiling in carbolated water. The hot water somewhat softened the insulation, which was subsequently hardened in cool air. I feared to use carbolized glycerin to lubricate the needles before introduction, lest this would also disturb the insulation. The use of unsterilized glycerin or oil was considered unsafe because of the danger of sepsis, so the needles were passed after being simply remoistened in water. The canulated needle carrying the wire was inserted to within half an inch of its hilt. A platinum needle was also used, which was passed until it was thought that the insulated part was fully within the sac. I had primarily intended introducing the canulated needle in the upper, most prominent, and apparently the thinnest part of the sac wall, in a downward direction, as nearly as possible parallel with the long axis of the body, hoping in this way to favor coagulation that would protect the exterior wall, but little guarded by clot. Mr. Flemming had made for me four platinum needles of good calibre, two inches in length and insulated to the extent of one inch. These I had also intended introducing below and over the most prominent parts of the sac, in a direction perpendicular to that of the canulated one, connected with the same rheophore, thinking that I might thus be able to secure the formation of multiple coagula extending from the wire to the needles and sac wall, and thus nearly consolidate the sac. Unfortunately for my purpose, it was found impossible to insert the canulated needle above in the direction desired, there still remaining some portions of the ribs yet unabsorbed, which interfered with its introduction. A trial was made in two places, but so much pain and disturbance of the sac was caused by my effort that I desisted, passing the needle below, in an upward direction, with the patient reclining prone.

Two and a half ~~inches~~ feet of wire were now slowly inserted, the distal end of the wire being first blunted by filing. An effort was now made to introduce the platinum needles. These, however, because of their cutting ends not being spear- or lancet-shaped, could be passed only with the greatest difficulty, the use of oil not being feasible, so that but one of the four was entered. The current was gradually increased through the controller until seventy milliampères were reached, and was maintained at this strength for one hour. The negative (indifferent) electrode was a very large felt plate, which lay upon the right shoulder and scapula, and was kept constantly moist with hot water. Notwithstanding this, and also that its situation was altered as much as space would permit, the large surface covered was the seat of intense pain, so that the current was momentarily opened through the rheostat to place a large folded, thoroughly-wet towel beneath the plate—a method I had before found to be of service when much pain is experienced from the contact of the felt when very strong currents are employed. Pain was unnoticed here after this, and none was experienced at the site of the active pole in either needles or sac. The pulse became quite feeble during the early part of the electrical treatment, but this weakness was not maintained, the patient standing the ordeal well. Considerable difficulty was encountered in withdrawing the needles, due evidently to the firmness of

the clot about them. I preferred not to practise a reversal of the current before their withdrawal, as has been recommended in the electrolysis of aneurism, lest the coagulum forming about the anode be softened by cathodic action. By gentle and continuous rotation and slight traction, with lateral pressure on the sac walls, they were removed, being also aided by an ingenious thought of Dr. Pottberg's, that of taking the lid of a stiff pasteboard pillbox, parting it from its periphery to its centre, and slipping it about the needle's base. Pressure made upon this by the fingers, instead of directly on the sac, enabled more counter-force to be utilized in withdrawal. Before removing the needles an attempt was made to push the portion of wire yet within the canula into the sac. This procedure does not commend itself to my judgment, as it appears that such a method must inevitably disturb the relation obtained by electrolysis between the wire, clot, and sac wall, loosening the coagulum if attached to the sac. But a small portion had been passed in when blood appeared at the canula's extremity, and at the same time the patient stated that he felt something moving within, the first sensation that had been noticed in the sac. The needle was now cautiously withdrawn in the manner stated, the wire cut close to the skin and gently pushed beneath the latter, after drawing the skin as a cover over the wire.[1] During the introduction of the canulated needle blood spurted on the needle entering the sac wall to about the depth of one-third to one-half of an inch, this indicating the extreme thinness of wall, covered by skin, fascia, and muscle, and supposed to be lined by a certain amount of clot. Hemorrhage ceased on passing the wire into the canula. None occurred on withdrawing the needles. Their site of exit was sealed with cotton soaked in iodoform collodion.

The condition of both needles on withdrawal showed unquestionable clot formation about them. Both insulated and uninsulated portions of the platinum one, as far as it had penetrated into the sac cavity, were covered with thick, white, tenacious fibrin, in appearance resembling white paint. The steel canulated one was heavily coated with clot, and its uninsulated portion was partly decomposed, a slight touch on the cutting extremity crumbling it beneath the finger.

A few hours subsequently the sac felt warmer than before, indicating inflammatory reaction, and pulsation seemed much less expansile. Considerable pain was felt in the centre and left side of the abdomen, but no more than had been present before the electrolysis. This was relieved by the passage of flatus and feces. Small doses of morphine and chloral were ordered should the pain become unbearable without their administration, the utmost quiet in recumbency was enjoined, and but little fluid in the shape of drink or food permitted. The patient was very uneasy, as he had been before the operation, though for several days pain was not so severe as formerly, but the same amount of opiate was taken. It was impossible to keep him at rest. He tossed about the bed constantly, and could not be restrained at times from walking about the room. Despite this, a remarkable change was noticed in the condition of the aneurism when the latter was examined on the third day. The prominent pulsating portion through which the canulated needle had been passed had sunken to the level of the general aneurismal surface, and

[1] The skin had been pushed to one side in introducing the needles in order to form a valve-like opening.

transmitted pulsation alone could be detected in it. The whole of the lower part of the sac felt much firmer, and was quite without pulsation, while the extreme upper part seemed to have undergone no change. Yet all parts of the trunk about the sac above and below, laterally and anteriorly, could now be handled lightly and with varying degrees of pressure without the slightest discomfort on the part of the patient, the heightened tactile- and pain-sensibility having entirely disappeared, as had likewise the much-increased superficial reflexes. The tendon reflexes in the legs were not again tested. For several days the pain seemed less. Little, if any, darting pain occurred, but the gnawing sensation was felt deeply in the abdomen, probably due to erosion of vertebræ, and after the fourth or fifth day it became as severe as before. At the end of the ninth day succeeding the operation, immediately after the patient had been tossing himself about on the bed from the prone to the supine position and had been thumping his left side with his fist—a practice he was addicted to when in pain, and which he insisted upon pursuing though aware of its danger—he suddenly called for a cuspidor that he might spit, and almost immediately a gush of blood came from his mouth, and in a few seconds he was dead.

A necropsy was made eight hours succeeding death. Body had been placed in dorsal position; it was still warm. Blood oozed from the mouth when turned upon the side. The former aneurismal bulging had disappeared. On opening the abdomen the sac was not discernible without displacing the stomach and intestines. On removal of the sternum the left lung appeared collapsed. The anterior surface of the left pleural cavity was filled with fluid and clotted blood. The right lung was normally distended with air. Pleural adhesions existed on both sides above, laterally, and posteriorly. The pericardium contained a normal amount of fluid. The heart was one and a half times the size of the closed fist. Left ventricle especially hypertrophied. The valves were normal. The ascending and transverse aorta was slightly dilated saccularly, and the seat of extensive atheromatous degeneration. The spleen was six inches in length, five inches in width, and one and a half inches in thickness. Its anterior surface was adherent to the capsule of the left lobe of the liver, two and a half inches of which extended across a good part of the spleen. The anterior and posterior upper margins of the spleen and about one-half of the upper posterior portion were intimately bound to the aneurism, which lay above it and tended to push the spleen downward and forward.

The sac extended from a point about opposite the right nipple obliquely downward and to the left, across the bodies of the ninth, tenth, and eleventh dorsal vertebræ to the lower edge of the twelfth rib on the left, filling the hypochondrium and a part of the lumbar region. It was twelve inches in its oblique measurement, four inches in transverse diameter above on the right, and six inches below on the left. The aneurism had arisen from the posterior and left lateral wall of the lower thoracic aorta, and subsequently had involved a portion of the abdominal aorta. It had advanced beneath the base of the left lung, and thence downward, the diaphragm forming a partial covering. The anterior wall of the aorta was plainly discernible crossing the sac, the orifice of which measured two inches in length. An effort was made to remove the sac entire without disturbance of its contents, and the left lung with it, into which rupture had occurred. This was found to be

impossible without mutilation of the exterior of the body, forbidden by the relatives. The boundaries of the aneurism, including, as they did, vertebræ and the greater portion of the posterior part of the right trunk, prevented the enucleation of the thin-walled sac without coincident removal of these structures. The sac was, therefore opened *in situ*. It was yet distended with about a quart of clot and some fluid blood. The site of rupture—a one and a half inch tear—was in the upper left portion, the rip extending into the base of the lung, and thence upward toward the posterior part of the apex of the superior lobe and through the visceral pleura. The wire lay in coils in the sac. The highest portion of the most superficial coil was about two and a half inches below the point of rupture. The distal extremity of the wire lay in the same situation, its point curved somewhat away from the ruptured portion of the sac. The wire was adherent below to the sac wall, but whether by clot or through its proximal portion not having completely entered the sac, I could not discover, as when an effort was made to ascertain this the wire and coagula had become loosened in the cavity through a second attempt being made to remove the sac. Firm clots existed in all portions of the aneurism, with softened ones evidently of very recent origin. The wire was engaged in several large, firm clots which were of so solid a texture that when examined in that part of the sac which was removed they could be separated from sac and wire only with some difficulty.

The bodies of the lower dorsal vertebræ were much eroded, the spinal cord, protected only by its membranes and thin laminated fibrin, lying exposed in the sac. These vertebræ formed part of the sac wall, as did also the inner surface of the posterior and lateral portions of the inferior ribs on the left. These ribs, in parts, had almost entirely disappeared. All portions of the periphery of the sac contained more or less white, laminated coagulum, some of which had undergone organization. The rent in the sac extended through laminated clot and sac wall into the base of the lung, ploughing for itself a sinus of some size. The calibre of the greater portion of the transverse colon and all its descending portion were much narrowed. The other abdominal viscera were normal. There were cretaceous nodules at the apex of the left lung.

Although these cases were treated by a similar method, a glance at the histories indicates that their character is so diverse as regards susceptibility of cure, and the application of the method so varied, that it is impossible to draw deductions from the results as a whole as to the utility of the procedure. The latter can only be arrived at by individual survey of each.

The cases of Corradi (Burresi's), Barwell, Roosevelt, and Abbe were apparently hopeless prior to operation, as was my own. In these, more than decided amelioration in the symptoms could not be expected. In the first case of Kerr's, that of fusiform aortic aneurism, this treatment could, of course, be of slight avail. In the remaining two cases, those of Kerr and Rosenstein, the results were decidedly beneficial, in the latter's absolutely curative; in Kerr's the patient was lost sight of, but not until subjective symptoms had entirely disappeared. The fact that

he promised to return should the symptoms recrudesce, tends at least to indicate that this case has also remained well.

In Corradi's case the chances of cure by any method were most remote. The decided temporary benefit following the operation, indicating prompt clot-formation, shows, however, the possibilities of this procedure, which, as practised by Corradi, was faulty in the small quantity of wire used, and in the fact that the wire was not spirally wound before introduction.

In Barwell's case, despite its unfavorable nature, undoubted signs of consolidation in the sac resulted, a fatal issue being due to rupture of a second sac into which the wire was not passed. The presence of firm decolorized fibrin adherent to the wire and sac illustrated the beneficial effects of the electrolysis. Although a current of much greater strength than ten milliampères would probably have been still more productive of good, the final result would have been, of course, similar.

In the case of Roosevelt the amount of wire used—two hundred and twenty-five feet—was probably much in excess of that necessary to fill the sac with coils and sufficient to interfere with subsequent contraction of the aneurism, had the case been susceptible of cure by this method. In Abbe's case one hundred feet of catgut had been introduced nine days prior to the insertion of one hundred and fifty feet of fine steel wire, a quantity greater than could be attended with the best ultimate results had a cure been within the range of probabilities. Here, too, the method was faulty, in that the polarity of the current was reversed after fifty milliampères had been passed by the anode for a half hour; the effect of one hundred milliampères through the negative pole for the same time subsequently, probably being to soften and partly dissolve the firm coagulum formed about the positive pole.

In these four cases fine steel wire was used. In Kerr's cases and in Rosenstein's and my own case, silver wire was employed. Kerr used ten feet of silver wire of a calibre somewhat greater than the bore of a medium-sized hypodermatic needle which it was drawn to fit. Rosenstein used two and one-sixth feet of softened silver wire. In my case, two and one-half feet of drawn wire of rather large calibre were inserted.

As the immediate cause of death in a number of cases in which filiform material was used has been rupture of the sac, it is important to inquire as to the influence of introduced substances, and especially wire, in its production. Rupture may follow the insertion of filiform material of any sort, in consequence of the partial obliteration of the sac cavity by formed coagula resulting in rapidly raised pressure on an unprotected and weakened portion of the sac now exposed to a greater pressure than formerly. This was probably the cause of rupture in Barwell's case and my own, as well as in those of Domville, Ransohoff,

and others,[1] in which a necropsy showed that no wire lay near the site of rupture. With the use of too firm a wire, or of wire in too great quantity, rupture is especially to be feared as a result of its interfering mechanically with contraction of fibrin and sac wall, and tending by its resistance to weaken a part of the latter. If steel wire be used, an additional danger may lie in the likelihood of its fracture in several places during contraction of the consolidated aneurism. The sharp extremities of these broken portions might be productive of great damage to the sac wall. Rupture apparently is only likely from the direct action of the wire when unyielding material, such as steel or highly-drawn silver, is used, or when an excessive amount of wire of any sort is introduced. Therefore, while it is important that the wire used should be sufficiently firm to be readily introduced, it must, on the contrary, not have so much permanent spring as to resist contraction of the clot of which it must necessarily form a part. Soft iron wire has been especially recommended by Steavenson,[2] as best fulfilling the various indications. He suggests that during the passage of the current soft iron wire would undergo decomposition, with the formation of chloride and oxide of iron, which would in addition exercise their own specific coagulating property. I was at first much inclined to the use of soft iron wire in preference to wire of other metals, until I undertook some experiments as to the influence of currents on the former, the result of which has caused me to prefer a wire less likely to be decomposed by the battery. In passing a current of fifty milliampères for one hour's time through ten feet of No. 36 soft iron wire, connected with the positive pole, and placed in twenty ounces of three-quarter per cent. salt solution, the circuit closed by the cathode in the fluid but not in contact with the anodal wire, an amount of detritus resulted, representing iron chloride and oxide, from the decomposition that had occurred between the wire and the solution under the influence of the current, that would be dangerous to release in an aneurismal sac. A portion of it would, of course, become engaged in the forming clot; another portion, however, might readily be carried into the circulation, and provoke the formation of thrombi elsewhere. A current of much less strength had a proportionately similar effect; that of ten milliampères for the same time also caused the formation of much sediment. Since it is of the utmost importance that a firm thrombus be promptly formed about the wire, and as this is more likely to result through the passage of a strong current for a considerable time, such as fifty to seventy milliampères for one hour, and since this strength

[1] In these, coagula forming about the wire had not completely filled the sac. In my case the sac was of such dimensions that the spirals did not reach much beyond the upper half, the wire having been introduced from below, and but two and one-half feet having been used.

[2] Lancet, July 11, 1887.

of current for this time, carefully applied, is attended with no more risk than a less strength for a briefer time, it is important that the ampèrage be high and the session long. But this would be attended with the above-mentioned danger if soft iron wire were used, and as steel is also objectionable for the reason before stated, wire of another metal, such as silver, is to be preferred. Silver salts will not be formed under the current's influence in appreciable quantity, and yet the wire will be sufficiently corroded to favor the deposit of fibrin upon it. The wire should be fine, and should be drawn just sufficiently hard to be readily passed through the canula forming spirals in the sac of about the size desired.[1] The cases apparently in which the best results were obtained, both when wire alone was used and when reënforced by galvanism, were those in which ten feet or less of wire were introduced.[2]

As Kerr remarks, six to ten feet are sufficient to introduce into any aortic aneurism, the object being merely to favor deposition of fibrin, and at the same time to provide a supporting matrix for the clot. As a means of demonstrating that but little wire is essential, he suggests the passage into a bottle the size of the aneurism, through a perforated cork, of sufficient wire to fill it with loops. It then will be seen how few feet are necessary to come into contact with all parts of the bottle's interior. He believes, also, that when a greater amount than ten feet is employed there is danger of the excess passing away in loops into other portions of the vessel, or, when the sac is in juxtaposition to the heart, of its entering the ventricle.

[1] Kerr (loc. cit.) directs that the calibre of the wire selected be somewhat larger than the diameter of the canula, and that it be drawn through a plate until it develops spring enough not to "kink." It must not, however, be overdrawn, as in such a case it will not coil away from the point of the canula, but will impinge on the opposite wall of the sac, as was the case in a third patient upon whom Kerr attempted the introduction of wire.

[2] Loretta's case, practically cured when death occurred, ten feet; Morse's case, cured, four and a half feet; Kerr's case, thought to be a cure, ten feet; Rosenstein's case, cured, two and one-sixth feet.

2620 North Fifth Street, Philadelphia.